

**What Is Claimed Is:**

- 1           1.       A method for generating code to perform anticipatory prefetching  
2 for data references, comprising:  
3           receiving code to be executed on a computer system;  
4 analyzing the code to identify data references to be prefetched; and  
5           inserting prefetch instructions into the code in advance of the identified  
6 data references, wherein inserting the prefetch instructions involves,  
7                   attempting to calculate a stride value for a given data  
8                   reference within a loop,  
9                   if the stride value cannot be calculated, setting the stride  
10                  value to a default stride value, and  
11           inserting a prefetch instruction to prefetch the given data reference for a  
12 subsequent loop iteration based on the stride value.
- 1           2.       The method of claim 1, further comprising allowing a system user  
2 to specify the default stride value.
- 1           3.       The method of claim 1, wherein calculating the stride value  
2 involves:  
3           identifying an induction variable for the stride value;  
4           identifying a stride function for the stride value; and  
5           calculating the stride value based upon the stride function and the  
6 induction variable.
- 1           4.       The method of claim 1, wherein inserting the prefetch instruction  
2 based on the stride value involves:  
3           calculating a prefetch cover distance by dividing a cache line size by the

4 stride value;  
5 calculating a prefetch ahead distance as a function of a prefetch latency,  
6 the prefetch cover distance and an execution time of a loop; and  
7 calculating a prefetch address by multiplying the stride value by the  
8 prefetch cover distance and the prefetch ahead distance and adding the result to an  
9 address accessed by the given data reference.

1 5. The method of claim 1, wherein analyzing the code involves:  
2 identifying loop bodies within the code; and  
3 identifying data references to be prefetched from within the loop bodies.

1 6. The method of claim 5, wherein analyzing the code to identify data  
2 references to be prefetched involves examining a pattern of data references over  
3 multiple loop iterations.

1 7. The method of claim 1, wherein analyzing the code involves  
2 analyzing the code within a compiler.

1 8. A computer-readable storage medium storing instructions that  
2 when executed by a computer cause the computer to perform a method for  
3 generating code to perform anticipatory prefetching for data references, the  
4 method comprising:  
5 receiving code to be executed on a computer system;  
6 analyzing the code to identify data references to be prefetched; and  
7 inserting prefetch instructions into the code in advance of the identified  
8 data references, wherein inserting the prefetch instructions involves,  
9 attempting to calculate a stride value for a given data  
10 reference within a loop,

11                   if the stride value cannot be calculated, setting the stride  
12                   value to a default stride value, and  
13                   inserting a prefetch instruction to prefetch the given data  
14                   reference for a subsequent loop iteration based on the stride value.

1           9.       The computer-readable storage medium of claim 8, wherein the  
2   method further comprises allowing a system user to specify the default stride  
3   value.

1           10.     The computer-readable storage medium of claim 8, wherein  
2   calculating the stride value involves:  
3           identifying an induction variable for the stride value;  
4           identifying a stride function for the stride value; and  
5           calculating the stride value based upon the stride function and the  
6   induction variable.

1           11.     The computer-readable storage medium of claim 8, wherein  
2   inserting the prefetch instruction based on the stride value involves:  
3           calculating a prefetch cover distance by dividing a cache line size by the  
4   stride value;  
5           calculating a prefetch ahead distance as a function of a prefetch latency,  
6   the prefetch cover distance and an execution time of a loop; and  
7           calculating a prefetch address by multiplying the stride value by the  
8   prefetch cover distance and the prefetch ahead distance and adding the result to an  
9   address accessed by the given data reference.

1           12.     The computer-readable storage medium of claim 8, wherein  
2   analyzing the code involves analyzing the code within a compiler.

1           13.     An apparatus that generates code to perform anticipatory  
2     prefetching for data references, comprising:  
3           a receiving mechanism that is configured to receive code to be executed  
4     on a computer system;  
5           an analysis mechanism that is configured to analyze the code to identify  
6     data references to be prefetched; and  
7           an insertion mechanism that is configured to insert prefetch instructions  
8     into the code in advance of the identified data references;  
9           wherein the insertion mechanism is configured to,  
10                  attempt to calculate a stride value for a given data reference  
11                  within a loop,  
12                  set the stride value to a default stride value if the stride  
13                  value cannot be calculated, and to  
14                  insert a prefetch instruction to prefetch the given data  
15                  reference for a subsequent loop iteration based on the stride value.

1           14.     The apparatus of claim 13, further comprising a configuration  
2     mechanism that is configured to receive the default stride value from a system  
3     user.

1           15.     The apparatus of claim 13, wherein while calculating the stride  
2     value, the insertion mechanism is configured to:  
3           identify an induction variable for the stride value;  
4           identify a stride function for the stride value; and to  
5           calculate the stride value based upon the stride function and the induction  
6     variable.

1           16.     The apparatus of claim 13, wherein the insertion mechanism is  
2 configured to:  
3           calculate a prefetch cover distance by dividing a cache line size by the  
4 stride value;  
5           calculate a prefetch ahead distance as a function of a prefetch latency, the  
6 prefetch cover distance and an execution time of a loop; and to  
7           calculate a prefetch address by multiplying the stride value by the prefetch  
8 cover distance and the prefetch ahead distance and adding the result to an address  
9 accessed by the given data reference.

1           17.     The apparatus of claim 13, wherein the apparatus resides within a  
2 compiler.

1           18.     A method for generating code to perform anticipatory prefetching  
2 for data references, comprising:  
3           receiving code to be executed on a computer system;  
4           analyzing the code to identify data references to be prefetched; and  
5           inserting prefetch instructions into the code in advance of the identified  
6 data references so that multiple prefetch instructions are issued for a given data  
7 reference;  
8           whereby the given data reference is prefetched even if the computer  
9 system drops a prefetch instruction for the given data reference.

1           19.     The method of claim 18, wherein inserting prefetch instructions  
2 involves ensuring that the multiple prefetch instructions for the given data  
3 reference are issued at different times, so that a single event is unlikely to cause  
4 all of the multiple prefetch instructions for the given data reference to be dropped  
5 by the computer system.

1           20.     The method of claim 18, wherein inserting prefetch instructions  
2 involves issuing each of the multiple prefetch instructions for the given data  
3 reference in a different loop iteration.

1           21.     The method of claim 18, wherein analyzing the code involves:  
2 identifying loop bodies within the code; and  
3 identifying data references to be prefetched from within the loop bodies.

1           22.     The method of claim 21, wherein analyzing the code to identify  
2 data references to be prefetched involves examining a pattern of data references  
3 over multiple loop iterations.

1           23.     The method of claim 18, wherein analyzing the code involves  
2 analyzing the code within a compiler.

1           24.     A computer-readable storage medium storing instructions that  
2 when executed by a computer system cause the computer system to perform a  
3 method for generating code to perform anticipatory prefetching for data  
4 references, the method comprising:  
5           receiving code to be executed on the computer system;  
6           analyzing the code to identify data references to be prefetched; and  
7           inserting prefetch instructions into the code in advance of the identified  
8 data references so that multiple prefetch instructions are issued for a given data  
9 reference;  
10           whereby the given data reference is prefetched even if the computer  
11 system drops a prefetch instruction for the given data reference.

1           25.     The computer-readable storage medium of claim 24, wherein  
2     inserting prefetch instructions involves ensuring that the multiple prefetch  
3     instructions for the given data reference are issued at different times, so that a  
4     single event is unlikely to cause all of the multiple prefetch instructions for the  
5     given data reference to be dropped by the computer system.

1           26.     The computer-readable storage medium of claim 24, wherein  
2     inserting prefetch instructions involves issuing each of the multiple prefetch  
3     instructions for the given data reference in a different loop iteration.

1           27.     The computer-readable storage medium of claim 24, wherein  
2     analyzing the code involves analyzing the code within a compiler.

1           28.     An apparatus that generates code to perform anticipatory  
2     prefetching for data references, comprising:  
3             a receiving mechanism that is configured to receive code to be executed  
4     on a computer system;  
5             an analysis mechanism that is configured to analyze the code to identify  
6     data references to be prefetched; and  
7             an insertion mechanism that is configured to insert prefetch instructions  
8     into the code in advance of the identified data references so that multiple prefetch  
9     instructions are issued for a given data reference;  
10            whereby the given data reference is prefetched even if the computer  
11     system drops a prefetch instruction for the given data reference.

1           29.     The apparatus of claim 28, wherein the insertion mechanism is  
2     configured to ensure that the multiple prefetch instructions for the given data  
3     reference are issued at different times, so that a single event is unlikely to cause



4 all of the multiple prefetch instructions for the given data reference to be dropped  
5 by the computer system.

1 30. The apparatus of claim 28, wherein the insertion mechanism is  
2 configured to issue each of the multiple prefetch instructions for the given data  
3 reference in a different loop iteration.

1 31. The apparatus of claim 28, wherein the apparatus resides within a  
2 compiler.

1 32. A method for generating code to perform anticipatory prefetching  
2 for data references, comprising:  
3 receiving code to be executed on a computer system;  
4 analyzing the code to identify data references to be prefetched; and  
5 inserting prefetch instructions into the code in advance of the identified  
6 data references;  
7 wherein inserting the prefetch instructions involves,  
8 identifying a location in the code where a prefetch address  
9 for a given prefetch instruction is calculated, and  
10 inserting the given prefetch instruction as far ahead of a  
11 corresponding data reference operation as possible, but not before  
12 the location where the prefetch address is calculated.

1 33. The method of claim 32, wherein inserting the given prefetch  
2 instruction can involve inserting the given prefetch instruction into a preceding  
3 block in the code.



1           34.     The method of claim 33, wherein inserting the given prefetch  
2 instruction involves:  
3           tracing execution of the code to produce an execution trace;  
4           using the execution trace to identify a preceding block in which the  
5 prefetch address is calculated; and  
6           inserting the given prefetch instruction into the preceding block after the  
7 location where the prefetch address is calculated.

1           35.     The method of claim 32, wherein analyzing the code involves:  
2 identifying loop bodies within the code; and  
3 identifying data references to be prefetched from within the loop bodies.

1           36.     The method of claim 35, wherein analyzing the code to identify  
2 data references to be prefetched involves examining a pattern of data references  
3 over multiple loop iterations.

1           37.     The method of claim 32, wherein analyzing the code involves  
2 analyzing the code within a compiler.

1           38.     A computer-readable storage medium storing instructions that  
2 when executed by a computer cause the computer to perform a method for  
3 generating code to perform anticipatory prefetching for data references, the  
4 method comprising:  
5           receiving code to be executed on a computer system;  
6           analyzing the code to identify data references to be prefetched; and  
7           inserting prefetch instructions into the code in advance of the identified  
8 data references;  
9           wherein inserting the prefetch instructions involves,

1 identifying a location in the code where a prefetch address  
2 for a given prefetch instruction is calculated, and  
3 inserting the given prefetch instruction as far ahead of a  
4 corresponding data reference operation as possible, but not before  
5 the location where the prefetch address is calculated.

1 39. The computer-readable storage medium of claim 38, wherein  
2 inserting the given prefetch instruction can involve inserting the given prefetch  
3 instruction into a preceding block in the code.

1 40. The computer-readable storage medium of claim 38, wherein  
2 inserting the given prefetch instruction involves:  
3 tracing execution of the code to produce an execution trace;  
4 using the execution trace to identify a preceding block in which the  
5 prefetch address is calculated; and  
6 inserting the given prefetch instruction into the preceding block after the  
7 location where the prefetch address is calculated.

1 41. The computer-readable storage medium of claim 38, wherein  
2 analyzing the code involves analyzing the code within a compiler.

1 42. An apparatus that generates code to perform anticipatory  
2 prefetching for data references, comprising:  
3 a receiving mechanism that is configured to receive code to be executed  
4 on a computer system;  
5 an analysis mechanism that is configured to analyze the code to identify  
6 data references to be prefetched; and

7           an insertion mechanism that is configured to insert prefetch instructions  
8   into the code in advance of the identified data references;  
9           wherein the insertion mechanism is configured to,  
10                  identify a location in the code where a prefetch address for  
11                  a given prefetch instruction is calculated, and to  
12                  insert the given prefetch instruction as far ahead of a  
13                  corresponding data reference operation as possible, but not before  
14                  the location where the prefetch address is calculated.

1           43.    The apparatus of claim 42, wherein the insertion mechanism is  
2   configured to insert the given prefetch instruction into a preceding block in the  
3   code.

1           44.    The apparatus of claim 43, wherein the insertion mechanism is  
2   configured to:  
3                  trace execution of the code to produce an execution trace;  
4                  use the execution trace to identify a preceding block in which the prefetch  
5                  address is calculated; and to  
6                  insert the given prefetch instruction into the preceding block after the  
7                  location where the prefetch address is calculated.

1           45.    The apparatus of claim 42, wherein the apparatus resides within a  
2   compiler.